

A SURVEY OF METHODS USED TO REVEAL EYE DEFECTS IN SCHOOL CHILDREN*

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THIS STUDY WAS UNDERTAKEN as the result of many enquiries received from various Departments of Education and School Boards for advice as to the best methods of testing vision in school children. The need for a simple, efficient, inexpensive routine for testing the eyes of school children is recognized. This routine should produce a standard for referral for eye consultation. As a rule, children do not complain of their ocular defects, hence the observations of their parents, teachers and doctors, or some screening method done in their school must be relied upon. In surveying the literature, it will be noted that very few studies on children have been done, and of these the results frequently fail to agree.

Sloane¹ in 1940, developed the Massachusetts Vision test for school children, comprising the Snellen letter, a Maddox Rod reading for near and far, and a test for manifest hypermetropia using $+1.50$ spheres. He suggested referring for consultation those children having 20/25 vision in each eye or 20/30 or worse in either eye; having an esophoria greater than 6 or an exophoria greater than 8 prism dioptres at 20 feet; or having a manifest hypermetropia giving them 20/20 vision in one eye or 20/30 in each eye separately, with a $+1.50$ sphere.

Sulzman, Cook and Bartlett² in 1948, reported results of visual acuity measurements with the Orthorator, Sight-Screener, Telebinocular and the Snellen Letter charts. In order to compare the instruments with a reasonable standard, they developed the New London Charts, which are modified Snellen Charts. They found the Keystone Telebinocular, then available, inferior in validity and reliability to the Orthorator and the Sight-Screener. In their opinion, no choice between the other two instruments could be made. In every instance, the reliability of measure of acuity for distance was found to be greater than the reliability of measures for near. The reliability of measures with screening instruments was found to be slightly inferior to that of the

New London Chart. The screening devices were as reliable as the Snellen charts.

Shaffer³ in 1948, made a study of vision testing procedures using the Snellen "E" chart, the Massachusetts Vision Test, and the Keystone Telebinocular. He found the Snellen chart at 20 feet the most reliable single test, when carried out successfully with proper illumination. The Telebinocular was satisfactory, but picked out too many unnecessary referrals, while the Massachusetts Vision Test was not selective enough in picking out referrals. As a basis for consultation he suggested a visual acuity of 20/40 or worse in either eye for ages seven or less, and 20/30 or worse for children over seven years.

Imus⁴ in 1949, made a survey of visual testing reliability of the commercial machines and found the machine tests could be used to predict clinical factors with a fair degree of accuracy and consistency. He found the Orthorator slightly more reliable and valid than the other devices. For vertical and lateral phorias he found the Orthorator slightly more consistent but the correlation coefficient was relatively low for all instruments.

PROCEDURE USED IN PRESENT SURVEY

The common eye tests used in the Toronto area were studied. Twelve hundred children in two of Toronto's public schools were tested. These were divided into three groups, Kindergarten, Grades I and II, and Grades III to VIII inclusive, using the tests applicable to each age group. The sequence of testing was varied and only a few tests were done at any one time to eliminate fatigue. In an initial group of four hundred children the tests used included the Snellen Animal, illiterate "E", number and letter charts, the project-o-chart number, letter and illiterate "E" slides, the Bausch and Lomb Orthorator, the American Optical Sight-Screener and the Keystone Telebinocular, the Maddox Rod for distance and near, cover test at 15 inches, near point of convergence, synoptophore, Holmgren wools and American Optical Pseudo-isochromatic plates. External examination, cycloplegic refraction and fundus examination were made. A retest reliability for Snellen charts was determined by testing the same child on the same chart on different days.

In an additional group of 800 children the tests used included the Snellen animal and letter charts, project-o-chart illiterate "E" and letter

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slides, Maddox Rod for distance and near, cover test at 15 inches, near point of convergence and Pseudo-isochromatic plates. A cycloplegic refraction was done on all Kindergarten children, and in the other grades, every child with worse than 20/20 vision in either eye. The effect on visual

acuity of varying the illumination of a Snellen Letter chart from 5-10-15 foot candles was recorded.

VISUAL ACUITY

The distribution of results for the various methods used in assessing visual acuity from Kindergarten to Grade VIII is given in Tables I to IV. A high percentage of children of Kindergarten age have visions of 20/30 or worse, while in the older grades, especially from Grade III to VIII, the majority of children have visions equal to 20/20 or better.

In order to assess the extent to which the results of the various tests agreed, correlation coefficients were calculated comparing the various tests with the Snellen chart. The correlation coefficients are given in the first half of Table V. These indices may vary from 0 to 1, a coefficient of zero implying no relation while a coefficient of 1 implies a perfect relation. Tests of visual acuity at Kindergarten age are poorly correlated, whereas in Grade III to VIII the correlations of Snellen Letter and Number, project-o-chart letter and number are high. The

TABLE I.

DISTRIBUTIONS OF VISUAL ACUITY: KINDERGARTEN (% eyes with various visual acuities)				
Visual acuity	Snellen animal	Snellen "E"	Project-O-chart "E"	Telebinocular (far)
20/15.....				
20/20.....	2.6	18.6	35.2	11.4
20/25.....		16.5	2.6	8.4
20/30.....	26.1	32.0	54.4	19.2
20/40.....	26.5	20.6	5.7	21.0
20/50.....	25.7	9.3	0.4	
20/60.....		1.0	0.9	20.4
20/70.....			0.4	
20/80.....	12.2		0.4	
20/100 or worse....	7.0	2.1		19.8
Number of eyes.....	230	97	230	167

TABLE II.

DISTRIBUTIONS OF VISUAL ACUITY: GRADE I (% eyes with various visual acuities)				
Visual acuity	Snellen numbers	Project-O-chart numbers	Project-O-chart "E"	Telebinocular (far)
20/15.....	1.0	1.1	1.0	18.6
20/20.....	37.6	35.2	55.9	50.9
20/25.....		38.6	8.8	9.8
20/30.....	42.6	29.7	23.5	5.9
20/40.....	7.9	1.1	2.9	3.9
20/50.....	3.0	3.3	2.9	
20/60.....				7.8
20/70.....	2.0	1.1	2.9	
20/80.....				
20/100 or worse....	5.9		2.0	2.9
Number of eyes.....	101	91	102	102

TABLE III.

DISTRIBUTIONS OF VISUAL ACUITY: GRADE 2. (% eyes with various visual acuities)					
Visual acuity	Snellen letter	Snellen number	Project-O-chart letter	Project-O-chart number	Telebinocular (far)
20/15.....	6.5	3.0		3.0	38.7
20/20.....	22.6	19.4	77.4	6.0	35.7
20/25.....			10.7	28.4	4.8
20/30.....	33.9	44.8	3.0	25.4	6.0
20/40.....	17.7	13.4	1.2	17.9	3.6
20/50.....	3.2	7.5	1.8	4.5	
20/60.....	3.2		3.0		5.4
20/70.....		4.5	1.8	4.5	
20/80.....	8.1			1.5	
20/100 or worse....	4.8	7.5	1.2	9.0	6.0
Number of eyes.....	62	67	168	67	168

TABLE IV.

DISTRIBUTIONS OF VISUAL ACUITY: GRADES 3 to 8 (% eyes with various visual acuities)							
Visual acuity	Snellen letter	Snellen number	Project-O-chart letter	Project-O-chart number	Telebinocular (far)	Sight-Screener	Orthorator
20/15.....	27.1	14.9	49.9	22.6	55.5	19.6	21.3
20/20.....	35.7	43.1	26.0	41.2	30.3	43.7	53.9
20/25.....			4.2	13.0	2.4		10.9
20/30.....	22.1	25.1	10.1	11.7	2.2	29.3	10.3
20/40.....	6.5	8.1	2.0	4.0	4.6	2.7	1.4
20/50.....		0.9	0.3	0.8		1.4	1.4
20/60.....	1.8		1.1		1.9		
20/70.....		3.8	1.3	2.1		1.6	0.8
20/80.....	3.6		1.9	1.1		0.3	
20/100 or worse....	3.2	4.1	2.3	3.5	3.2	1.4	
Number of eyes.....	443	443	377	376	370	368	358

Orthorator, Telebinocular and Sight-Screener do not correlate as well, either with the Snellen letter chart or among themselves.

It was thought that these coefficients gave undue weight to discrepancies between the tests in the region of poor visual acuity. For this reason

test and less than 20/20 by the other. The percentage "misclassified" are given in the second half of Table V. It will be noted that these various values place the tests in the same general order as the correlation coefficients.

The test-retest correlations and percentages

TABLE V.

TEST INTERCORRELATIONS VISUAL ACUITY									
Test	Grade	SE	PE	SN	PN	PL	Telebinocular	Sight-screener	Orthorator
Snellen animal	Kindergarten	0.48	0.56				0.66		
Snellen number . . .	Grade 1		0.83		0.90		0.20		
Snellen letter	Grade 2			0.84	0.96	0.90	0.58		
Snellen letter . . .	Grade 3 to 8			0.94	0.94	0.96	0.75	0.83	0.67
Telebinocular . . .	Grade 3 to 8							0.77	0.68
Sight-screener . . .	Grade 3 to 8								0.60
TEST MISCLASSIFICATION									
% "misclassified"									
Snellen animal	Kindergarten	23	33				7		
Snellen number . . .	Grade 1		25		6		27		
Snellen letter . . .	Grade 2			11	22	18	23		
Snellen letter . . .	Grade 3 to 8			15	18	14	17	23	22
Telebinocular . . .	Grade 3 to 8							25	22
Sight-screener . . .	Grade 3 to 8								25

a further measure of the lack of agreement was devised by calculating the percentage of eyes having a visual acuity of 20/20 or better by one

TABLE VI.

RETEST CORRELATIONS VISUAL ACUITY			
Test	Grade	r	% "misclassified"
Snellen animal . .	Kindergarten	0.87	—
Snellen number . .	Grade 1	0.90	11
Snellen letter . . .	Grade 2	0.91	15
Snellen letter . . .	Grades 3 to 8	0.92	12

TABLE VII.

DISTRIBUTION OF REFRACTIVE ERRORS: KINDERGARTEN CYLINDERS					
Spheres	-2.0 to -0.25	0	+0.25 to +2.0	+2.0 to +4.0	Total
-2.0 to -0.25	1.0	3.0	2.0	—	6.0
0	—	5.0	5.0	—	10.0
+0.25 to +2.0	—	40.0	28.0	—	68.0
+2.0 to +4.0	—	5.0	11.0	—	16.0
Total	1.0	53.0	46.0	—	100.0%
Number of pupils	102				

TABLE VIII.

DISTRIBUTION OF REFRACTIVE ERRORS: GRADES 1 AND 2 CYLINDERS							
	-2.0	-2.0 to -0.25	0	+0.25 to +2.0	+2.0 to +4.0	+4.0	Total
<i>Spheres</i>							
-2.0.....						1.0	1.0
-2.0 to -0.25.....		3.0	2.0	3.0	2.0	1.0	11.0
0.....			4.0	3.0	1.0		8.0
+0.25 to +2.0.....			47.0	25.0			72.0
+2.0 to +4.0.....			2.0	5.0			7.0
+4.0.....					1.0		1.0
Total.....		3.0	55.0	36.0	4.0	2.0	100.0%
Number of pupils.....		160					

"misclassified" in the various grades with the appropriate Snellen charts are found in Table VI. The correlation coefficient is sufficiently high to make retesting unnecessary.

The distribution of refractive errors in Kindergarten, Grades I and II, and Grades III to VIII is given in Tables VII to IX. In Table X is given the distribution of refractive errors by ages. It is evident that the great majority of children are hypermetropic. From ages 5 to 14 the incidence of hypermetropia decreases, that of emmetropia and myopia increases, while mixed astigmatism remains relatively unchanged. The correlation of

cycloplegic refractive errors with visual acuity is uniformly poor.

MUSCLE BALANCE

The distribution of results for horizontal phorias at 15 inches and 20 feet is given in Table XI. The majority of children have no significant imbalance. It will be noted that over twice the number of children have esophorias ranging from 5 to 12 prism dioptres at 15 inches as compared with 20 feet. 1% of the children surveyed had hyperphorias ranging from 0 to 1 prism

TABLE IX.

DISTRIBUTION OF REFRACTIVE ERRORS: GRADES 3 TO 8 CYLINDERS							
	-2.0	-2.0 to -0.25	0	+0.25 to +2.0	+2.0 to +4.0	+4.0	Total
<i>Spheres</i>							
-2.0.....	0.5	0.2	0.2	0.5			1.0
-2.0 to -0.25.....	0.2	2.0	6.0	0.7	0.7	0.5	10.0
0.....		0.5	10.0	4.0	0.5		15.0
+0.25 to +2.0.....		0.2	47.0	21.0	0.5		69.0
+2.0 to +4.0.....			3.0	1.0	0.2		4.0
Total.....	1.0	3.0	66.0	27.0	3.0		100.0%
Number of pupils.....	420						

TABLE X.

DISTRIBUTION OF REFRACTIVE ERRORS BY AGES (% eyes with various refractive errors)										
Age	5	6	7	8	9	10	11	12	13	14
Emmetropia.....	2%	5%	8%	5%	3%	7%	7%	9%	10%	9%
Hypermetropia—Simple.....	48%	61%	42%	36%	47%	49%	34%	36%	26%	33%
S. Astig....	5%	6%	—%	4.5%	4%	4%	3%	1%	3%	2%
Comp. Astig.....	38%	21%	39%	40%	21%	29%	19%	37%	45%	33%
Myopia—Simple.....	1.4%	—	4%	3.5%	5%	3%	8%	5%	10%	4%
S. Astig.....	0.3%	1%	—	1%	—	—	19%	1%	—	5%
Comp. Astig.....	0.3%	—	1%	5.5%	5%	3%	5%	7%	6%	7%
Mixed astigmatism.....	5%	6%	6%	4.5%	15%	5%	5%	4%	—	7%
Number of eyes.....	231	97	84	111	80	94	113	98	38	60

TABLE XI.

DISTRIBUTION OF MUSCLE BALANCE: KINDERGARTEN—GRADE 8 (% of children with various amounts of horizontal phorias)									
Prism dioptres	Maddox rod (far)	Telebin- ocular (far)	Sight- screener (far)	Ortho- rator (far)	Maddox rod (near)	Telebin- ocular (near)	Sight- screener (near)	Ortho- rator	Synopto- phore
-13 to -20.....		1.1							3.3
-5 to -12.....	8.0	7.6	4.5	3.4	5.5	7.2	4.2	4.4	19.5
-4 to +4.....	86.0	83.2	87.4	94.5	71.4	79.8	77.1	76.6	50.2
+5 to +12.....	6.0	8.1	7.6	2.1	23.1	11.8	17.1	19.9	22.6
+13 to +20.....			0.5			1.2	1.6	1.1	4.4
Number of children.....	286	290	197	180	290	320	192	181	319

dioptries, 2.3% from 1 or 2 prism dioptries, and 0.5% over 2 prism dioptries. 2.1% of the total number of children had heterotropias of varying degree and of these 0.5% were amblyopic in one eye.

The correlations between the Maddox Rod and the other tests for measuring muscle balance are given in Table XII. These correlations are all poor.

COLOUR VISION

9.6% of the children failed the Orthorator colour vision test, 8.9% failed the Pseudo-iso-

TABLE XII.

TEST INTERCORRELATIONS: GRADE 3 TO 8 MUSCLE BALANCE NEAR TESTS				
	<i>Telebin-ocular</i>	<i>Orthorator</i>	<i>Sight-screener</i>	<i>Synoptophore</i>
Maddox rod....	.39	.53	.52	.60
Telebinocular...		.46	.56	.53
Orthorator.....			.57	.41
Sight-screener...				.62
		<i>Far tests</i>		
Maddox rod....	.25	.20	.27	
Telebinocular...		.36	.57	
Orthorator.....			.47	
Synoptophore...				

TABLE XIII.

DISTRIBUTION OF VISUAL ACUITY BY AGES (% eyes with various visual acuities)									
	7	8	9	10	11	12	13	14	Total
20/15.....	3.6	32.8	49.5	51.3	54.9	55.5	60.8	52.7	46.6
20/20.....	68.6	51.6	33.1	28.4	22.6	24.7	23.0	21.8	33.3
20/25.....	9.8	6.3	2.8	7.1	8.0	7.5	1.3	5.5	6.1
20/30.....	4.5	2.1	5.2	4.7	4.5	3.2	2.7	6.4	4.0
20/40.....	1.8	0.5	1.7	1.4	2.5	1.6	3.4	3.6	1.9
20/50.....	4.5	1.6	2.9	3.8	2.0	1.1	2.0	0.9	1.5
20/60.....	2.7	1.0	1.2	0.5	1.0	3.2	2.0	0.9	1.5
20/70.....	3.6	1.0	1.2	1.4	1.0		0.7	1.8	1.3
20/80.....		0.5	0.6		0.5	0.5	0.7	0.9	0.4
20/100 or worse..	0.9	2.6	1.7	1.4	3.0	2.7	3.4	5.5	2.6
Number of eyes..	112	192	172	211	199	186	148	110	1338

chromatic plates and 1.7% the Telebinocular colour vision chart. It is of interest that only one child failed all three tests.

ADDITIONAL RESULTS

The distribution of visual acuity by ages is given in Table XIII using the project-o-chart letters. A change in visual acuity is noted around nine years of age, when the majority of children with "normal" vision show an improvement in visual acuity from 20/20 to 20/15.

No significant change in visual acuity is found by varying the illumination of the Snellen chart from 5-10-15 foot candles.

Out of the total number of children examined 10.4% required a correction for the existing refractive error and of these 3.4% were already wearing an adequate correction, while 7% were uncorrected.

Fundus anomalies were found in 3% of the children refracted. These anomalies included changes in myopia, deep physiological cupping of the discs, and medullated nerve fibres. No significant pathological change was found on external or fundus examination during this survey.

CONCLUSIONS AND RECOMMENDATIONS

1. The Snellen illiterate "E" chart is an adequate test for visual acuity in the Kindergarten age group. A visual acuity of 20/30 in each eye can be regarded as normal. Children with visual acuity poorer than 20/30 in either eye should be referred for eye consultation.

2. In grades one to eight a visual acuity of 20/20 in each eye can be regarded as normal. The Snellen Number Chart is an adequate test

of visual acuity for children in Grade I, and the Snellen Letter Chart is adequate for children in Grades II to VIII. A child with vision poorer than 20/20-3 in either eye should be referred for eye consultation.

3. Adequate illumination of the Snellen chart is necessary. This should be about 10 foot candles and may be obtained by placing a goose-necked lamp with reflector on each side of the chart and about three feet from it. Each lamp should contain a 100 watt daylight bulb.

4. Snellen charts should be placed a distance of 20 feet from the subject. It is preferable to test each child alone without the distraction of other children.

5. Colour vision can be adequately tested by Holmgren wools in the Kindergarten age group, and by Pseudo-isochromatic or Ishihara plates in the older age groups.

6. No one test for the measurement of vertical and lateral phorias is better than any other, as all the tests correlated poorly. The amount of emphasis that should be placed on phorias in this age group is problematical. Any tropia should, of course, be referred for an ophthalmologist's opinion.

7. It would be advisable for persons doing eye testing in schools to have had some instruction either by lecture or by pamphlet in visual test-

ing, types of refractive errors, strabismus, and signs and symptoms suggesting ocular difficulties.

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THE DIABETIC IN INDUSTRY*

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THE PROBLEMS of the diabetic are many. One is that we do not know what causes diabetes. This is a problem for the physiologist. Another is how to make the best use of that which is known. This concerns the practising physician, —and one of his problems is education of the patient. But no less essential to the health and welfare of the diabetic is employment, and here, as will be seen, the solution is largely in education of the public.

The extent to which there is need of educating the public is seen in the many organizations which do not employ diabetics. A large life assurance company—The Metropolitan Life Insurance Company—does not employ them. A large industrial organization—The Edison Company of New York—does not employ them.¹ A Committee of the Association of American Railroads has expressed the belief that "no known diabetic should be hired".² These three examples could be multiplied many times.

The extent to which such practice and belief are capable of doing harm in Canada alone is seen in the number of diabetics in Canada, their ages, the rate at which the diabetic population

has increased in the last thirty years, and the rate at which it may be expected to increase.

The Dominion Bureau of Statistics, Department of Trade and Commerce, in estimating The Labour Force of Canada, includes all individuals of age 14 and over. If we include these ages of diabetics, we include about 90% of all diabetics. Assuming therefore, that the same percentage distribution of those with jobs and those without jobs³ applies to diabetics as to the general population of non-diabetics, there are in the labour force of Canada approximately 40,000 male diabetics and 11,000 female diabetics with jobs.

Though diabetes occurs at all ages—from the breast-fed infant to the nonagenarian—it is essentially a condition of people approaching and past middle life. Also, in most instances, diabetes is inherited. Therefore, as the average duration of life increases it may be expected that the diabetic population will increase, and thus the number of employable diabetics will increase. Since 1920, the diabetic population of Canada has about doubled, and here are the probabilities of the future: at all ages, from birth to age 45 years, the chances are that two of every one hundred males now alive will eventually become diabetics. In the female population, the probabilities at all ages, from birth to age 45 years, are that four of every one hundred now alive will eventually become diabetics. Of the popu-

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